C-5.1 Explain the effects of the intermolecular forces on the different phases of matter.

Revised Taxonomy Levels 2.7 B <u>Explain</u> conceptual knowledge

Students did not address this concept in physical science

It is essential for students to

- Diagram, describe, and give examples of the following intermolecular forces
  - Dipole-dipole attraction
    - Hydrogen bonding
  - London dispersion forces
- Compare intermolecular forces (dipole-dipole interaction, and London dispersion forces) and ionic bonds, covalent bonds, and metallic bonds in terms of
  - Nature of the attraction
  - type of substance
  - structural unit
  - examples
  - typical properties

Type of Substance	Structural Unit	Inter-particle Force	Substance	Melting Point (1atm, ˚C)	Boiling Point (1atm, ˚C)
Non-polar Covalent (molecular)	molecule	London Dispersion Forces	H_2	-259	-253
			O_2	-218	-183
			CH_4	-182	-164
			CCl_4	-23	77
			C_6H_6	6	80
Polar Covalent (molecular)	molecule	Dipole-dipole interaction	H_2O	0	100
			H_2S		-61
			HCl		-85
			NH_3	-78	-33
Ionic	ion	Ionic bonds	NaCl	801	1413
			MgF_2	1266	2239
Metallic	atom	Metallic bonding	Cu	1083	2567
			Fe	1535	2750
			Hg	-39	357
			W	3410	5660
Covalent Network	atom	Covalent bonds	$(SiO_6)_x$	1610	2230
			C_x (diamond)	3500	3930

- Use a chart, such as the one above to compare the intermolecular forces present in substances with high, low, and moderate melting and boiling points.

- Discuss other factors, (in addition to the nature of the intermolecular force) which affect the melting and boiling point of a substance.

Assessment

The verb, explain means that the major focus of assessment should be for students to "construct a cause and effect model". In this case, assessments will ensure that students can model how intermolecular forces influence the melting point and boiling point of various types of substance. Because the indicator is written as conceptual knowledge, assessments should require that students understand the "interrelationships among the basic elements within a larger structure that enable them to function together." In this case, assessments must show that students can construct a cause and effect statement relating how the intermolecular forces, in the context of other factors, determine the properties of a substance.

C-5.2 Explain the behaviors of gas; the relationship among pressure, volume, and temperature; and the significance of the Kelvin (absolute temperature) scale, using the kinetic-molecular theory as a model.

Revised Taxonomy Levels 2.7 B Explain conceptual knowledge

Students did not address this concept in physical science

It is essential for students to

- Use the Kinetic Molecular Theory as a model to explain the relationship between, pressure, and volume in a gas sample.
- Explain the significance of the absolute temperature scale in terms of the Kinetic Molecular Theory.
  - Explain the relationship between temperature and average kinetic energy.

Assessment

The verb, explain means that the major focus of assessment should be for students to "construct a cause and effect model". In this case, assessments will ensure that students can use the Kinetic Molecular Theory as a model for the behavior of gasses. Because the indicator is written as conceptual knowledge, assessments should require that students understand the "interrelationships among the basic elements within a larger structure that enable them to function together." In this case, assessments must show that students can construct a cause and effect statement relating how each variable, (pressure, volume, and temperature), effects each of the others.

C-5.3 Apply the gas laws to problems concerning changes in pressure, volume, or temperature (including Charles's law, Boyle's law, and the combined gas law).

Revised Taxonomy Level 3.2 C_A <u>Apply</u> procedural knowledge

This concept was not addressed in physical science

It is essential for students to
- Explain Charles' law and Boyle's laws in terms of the kinetic molecular theory
- Solve gas law problems concerning changes in gas pressure, volume, or temperature.

Assessment
The revised taxonomy verb for this indicator is <u>implement</u> <u>(apply)</u> the major focus of assessment will be for students to show that they can "apply a procedure to an unfamiliar task". The knowledge dimension of the indicator, procedural knowledge means "knowledge of subject-specific techniques and methods" In this case the procedure for solving gas law problems using Charles' and Boyle's laws. A key part of the assessment will be for students to show that they can apply the knowledge to a new situation, not just repeat problems which are familiar. This requires that students have a conceptual understanding of gasses in terms of the Kinetic Molecular Theory.

C-5.4 Illustrate and interpret heating and cooling curves (including how boiling and melting points can be identified and how boiling points vary with changes in pressure).

Revised Taxonomy Level 2.2-B Exemplify (illustrate) conceptual knowledge

In physical science students

- Explain the process of phase change in terms of temperature, heat transfer, and particle arrangement (PS-3.7)
  - Physical science students explain phase change in terms of the Kinetic Molecular Theory
  - Physical science students explain why temperature vs. time graphs show constant temperature during phase change.

It is essential for students to

- Define phase changes in terms of kinetic energy of the particles, heat transfer, and particle orientation and arrangement.
  - melting
  - boiling
  - condensation
  - freezing
  - sublimation
- Differentiate the processes of evaporation and boiling
- Differentiate the terms gas and vapor
- Explain how atmospheric pressure and vapor pressure affect the boiling point of a substance
  - Analyze a phase diagram (temperature vs. pressure)
    - Explain triple point
    - Critical point
- Analyze a graph of temperature vs time which illustrates the heating or cooling of a substance over the range of phase change.
  - Explain the shape of the graph in terms of kinetic energy, potential energy, and heat transfer

- **Assessment**

The verb exemplify (illustrate) means to find a specific example or illustration of a concept or principle, therefore the major focus of assessment will be for students to give examples that show that they understand phase change in terms of the Kinetic Molecular Theory. Conceptual knowledge requires that students understand the interrelationships among the basic elements within a larger structure that enable them to function together. In this case, that students understand how pressure and temperature, and heat flow affect the kinetic energy, potential energy, and orientation of the particles of a substance.

The following five indicators (5.5 -5.9) should be selected as appropriate to a particular course for additional content and depth:

C-5.5 Analyze the energy changes involved in calorimetry by using the law of conservation of energy as it applies to temperature, heat, and phase changes (including the use of the formulas $q = mc\Delta T$ [temperature change] and $q = mLv$ and $q = mLf$ [phase change] to solve calorimetry problems). (additional content/depth)

Revised Taxonomy Level 4 <u>Analyze</u> conceptual knowledge

Students did not address this concept in physical science

It is essential for students to

- Differentiate between the terms temperature and heat in terms of the Kinetic Molecular Theory
- Understand the terms
  - gram specific heat
  - molar specific heat
  - heat of fusion
  - heat of vaporization
- Solve problems involving the heat required (or released) when a substance undergoes any combination of temperature and phase change.
- Solve problems involving the heat transferred from one substance to another when the two substances reach thermal equilibrium.
  - Determine the temperature change and the phase of each substance upon reaching equlibrium.

Assessment

The revised taxonomy verb for this indicator is analyze, which means to "break material into its constituent parts and determine how the parts relate to one another and to an overall structure or purpose". In this case, students should be able to consider a the energy changes that a substance or system of substances must experience in order to go from one phase and/or temperature to another. Because the indicator is written as <u>conceptual knowledge,</u> assessments should require that students understand the "interrelationships among the basic elements within a larger structure that enable them to function together."

C-5.6 Use density to determine the mass, volume, or number of particles of a gas in a chemical reaction.

Revised Taxonomy Level 3.2 C_A Apply (use) procedural knowledge

Students did not address this concept in physical science

It is essential for students to

- Understand the volume of a mole of any gas at STP is 22.4 l/mole
  - Use the combined gas law equation to find the volume of a gas under various conditions when given the volume at STP
- Use the molar volume of a gas to perform stoichiometric calculations for gasses.
  - Volume to volume
  - Mass to volume
  - Moles to volume
- Understand the quantitative relationship between density and molecular weight.
  - molecular weight divided by 22.4 liters per mole = density of a gas at STP

Assessment

The revised taxonomy verb for this indicator is implement (use), the major focus of assessment will be for students to show that they can "apply a procedure to an unfamiliar task". The knowledge dimension of the indicator, procedural knowledge means "knowledge of subject-specific techniques and methods" In this case the procedure for solving stoichiometric calculations for chemical reactions involving gasses. A key part of the assessment will be for students to show that they can apply the knowledge to a new situation, not just repeat problems which are familiar. This requires that students have a conceptual understanding of the way that pressure and temperature affect the volume and mass of a gas.

C-5.7 Apply the ideal gas law (pV = nRT) to solve problems.

Revised Taxonomy Level 3.2 C_A <u>Apply</u> procedural knowledge

Students did not address this concept in physical science

It is essential for students to

- Explain the ideal gas law in terms of the Kinetic Molecular Theory
- Understand the ideal gas constant, R has various forms and must be consistent with the units for the other variables.

Unit of R	Numerical value of R	Unit of P	Unit of V	Unit of T	Unit of n
$\frac{L \cdot mmHg}{mol \cdot K}$	**62.4**	**mm Hg**	**L**	**K**	**mol**
$\frac{L \cdot atm}{mol \cdot K}$	**0.0821**	**atm**	**L**	**K**	**mol**
$\frac{J}{mol \cdot K}$	**8.314***	**Pa**	**m^3**	**K**	**mol**
$\frac{L \cdot kPa}{mol \cdot K}$	**8.314**	**kPa**	**L**	**K**	**mol**
***note:** $1\ L \cdot atm = 101.325$ J; 1J = 1 $Pa \cdot m^3$					

- Use the ideal gas law equation to find pressure, volume, temperature, or number of moles.

Assessment

The revised taxonomy verb for this indicator is <u>implement</u> <u>(apply)</u>, the major focus of assessment will be for students to show that they can "apply a procedure to an unfamiliar task". The knowledge dimension of the indicator, procedural knowledge means "knowledge of subject-specific techniques and methods" In this case the procedure for solving problems using the ideal gas law equation. A key part of the assessment will be for students to show that they can apply the knowledge to a new situation, not just repeat problems which are familiar. This requires that students have a conceptual understanding of the ideal gas law.

C-5.8 Analyze a product for purity by following the appropriate assay procedures.

Revised Taxonomy Level 4 Analyze conceptual knowledge

Students did not address this concept in physical science

It is essential for students to

- Assay product purity using simple analytical chemical procedures.

Assessment

The revised taxonomy verb for this indicator is analyze which means to "break material into its constituent parts and determine how the parts relate to one another and to an overall structure or purpose". In this case, students should be able to analyze a chemical process and account for loss due to loss and error. Because the indicator is written as conceptual knowledge, assessments should require that students understand the "interrelationships among the basic elements within a larger structure that enable them to function together." In this case, assessments must show that students understand the reasons for the difference in the expected and actual values.